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(71)Applicant : FUJITSU LTD
(72)Inventor : ODAGIRI MITSURU
TAKEFUSA SANAE
MIYAKE HIROKO

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(54) MAGNETIC MATERIAL, MAGNETIC HEAD USING THE SAME AND MAGNETIC RECORDING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain yet superior high frequency characteristic, facilitate formation of a satisfactory magnetic domain structure which does not require heat treatment, improve high-frequency characteristic and magnetic recording capability and enable improvement in high frequency characteristic and high recording density of a thin-film magnetic head, in a magnetic head composed of a NiFeMo alloy.
SOLUTION: In a magnetic material composed of Ni, Fe and Mo, a composition ratio of Ni, Fe and Mo is set with Ni of 77-82 at%, Fe of 15-21 at%, Mo of less than 6 at%, and magnetostriction constant λs is selected so as to be in the range of $-1 \times 10-6 \leq \lambda s \leq 1 \times 10-6$. It is desirable that the composition ratio of Ni, Fe and Mo be so selected that coercive force Hc of this magnetic material be set Hc ≤1 Oe.

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CLAIMS

[Claim(s)]
[Claim 1] In the magnetic material which consists of nickel, Fe, and Mo, it is [ratio / composition / of NiFeMo / nickel] under 6 atom % about 15 to 21 atom %, and Mo in 77 to 82 atom %, and Fe, and is magnetostriction constant lambdas. Magnetic material characterized by choosing it as the range used as -1x10-6 <=lambdas <=0.
[Claim 2] Coercive force Hc of the above-mentioned magnetic material Magnetic material according to claim 1 characterized by choosing the composition ratio of NiFeMo so that it may be set to Hc <=1Oe.
[Claim 3] The magnetic material according to claim 1 or 2 characterized by choosing the composition ratio of NiFeMo so that the specific resistance rho of the above-mentioned magnetic material may be set to rho>=20microomegacm.
[Claim 4] Saturation magnetic flux density Bs of the above-mentioned magnetic material Magnetic material given in the claim 1 characterized by choosing the composition ratio of NiFeMo so that it may be set to Bs >=0.8T, or any 1 term of 3.
[Claim 5] The magnetic head characterized for the configuration which has compressive stress for a magnetic pole layer by nothing and constituting using the magnetic material of a publication in a claim 1 or any 1 term of 4.
[Claim 6] In the magnetic material which consists of nickel, Fe, and Mo, it is [ratio / composition / of NiFeMo / nickel] under 6 atom % about 15 to 21 atom %, and Mo in 77 to 82 atom %, and Fe, and is magnetostriction constant lambdas. Magnetic material characterized by choosing it as the range used as 0 <=lambdas<=1x10-6.
[Claim 7] Coercive force Hc of the above-mentioned magnetic material Magnetic material according to claim 6 characterized by choosing the composition ratio of NiFeMo so that it may be set to Hc <=1Oe.
[Claim 8] The magnetic material according to claim 6 or 7 characterized by choosing the composition ratio of NiFeMo so that the specific resistance rho of the above-mentioned magnetic material may be set to rho>=20microomegacm.
[Claim 9] Saturation magnetic flux density Bs of the above-mentioned magnetic material Magnetic material given in the claim 6 characterized by choosing the composition ratio of NiFeMo so that it may be set to Bs >=0.8T, or any 1 term of 8.
[Claim 10] The magnetic head characterized for the configuration which has a tensile stress for a magnetic pole layer by nothing and constituting using the magnetic material of a publication in a claim 6 or any 1 term of 9.
[Claim 11] The magnetic head characterized by constituting a magnetic-shielding layer using the magnetic material of a publication in a claim 1, 4, a claim 6, or any 1 term of 9.
[Claim 12] The magnetic recording medium using the magnetic head given in either of the claims 5, 9, and 11.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Especially this invention relates to the magnetic material which has the feature in the composition for improving the RF property of the induction-type head which constitutes the compound-die thin film magnetic head used for a magnetic recording medium or magnetic tape units, such as a hard disk drive (HDD), etc., and an MR head about a magnetic material, the magnetic head, and a magnetic recording medium, the magnetic head, and a magnetic recording medium.
[0002]
[Description of the Prior Art] In recent years, in connection with a rise of the request of the miniaturization of the hard disk drive unit which is the external storage of a computer, and large-capacity-izing, record frequency amounts to 100MHz (108 Hz), and is utterly. The stratification is carried out in piles one by one at a series of coat process so that it can respond to high-density record in a pitch narrow to the writing from a magnetic-recording medium, and read-out that it is a usual state for the read head the write head for record and for reproduction to be separately arranged for the magnetic head which bears the writing of record data and read-out in such a magnetic recording medium, and for it to be united, and to be constituted, and it should correspond, and a gap may put a recording head and a read head in order that it is few and
[0003] Such an up magnetic pole layer of the thin film magnetic head explains briefly an example of the conventional compound-die thin film magnetic head with reference to drawing 6 here, although the permalloy alloy of the nickel82Fe18 grade really formed with mask plating is used in many cases.
Drawing 6 reference drawing 6 is the important section transillumination perspective diagram having shown typically the conventional compound-die thin film magnetic head. On the aluminum2 O3-TiC substrate (not shown) used as the parent of a slider The lower shield layer 41 which consists of a NiFe alloy etc. through 2Oaluminum3 film (not shown) is formed. aluminum 2O3 etc., after forming the magnetoresistance-effect element 42 which consists of a laminated structure of NiFe, Ti, and NiFeCr etc. through a lower lead gap layer (not shown) and carrying out patterning to a predetermined configuration The electric conduction film which consists of Au etc. is made to deposit on the ends of the magnetoresistance-effect element 42, and the lead electrode 43 is formed.
[0004] subsequently -- again -- aluminum 2O3 The lower magnetic pole layer 44 which serves as the up shield layer which consists of a NiFe alloy etc. through an up lead gap layer (not shown) is formed. etc. -- moreover -- aluminum 2O3 etc. -- from, while forming the light level spiral-like coil 45 through lower layer insulation films (not shown), such as a resist, after preparing the becoming light gap layer (not shown) The up magnetic pole layer 47 of the configuration where formed the light electrode 46 in the ends, and the light pole 48 of **** was subsequently formed at the nose of cam through the up layer insulation film (not shown) which consists of a resist etc. is formed. Subsequently, it is aluminum 2O3 to the whole surface. After preparing a film and considering as a protective coat (not shown), The object for reproduction which used the magnetoresistance-effect element 42 by performing slider processing including

the grinding for cutting a substrate and adjusting the length of the light pole 48, i.e., the depth of gap, polish, etc., i.e., the MR head for a lead, The compound-die thin film magnetic head which composite-ized the object for record, i.e., the thin film magnetic head of the induction type for lights, is obtained. In this case, the magnetic flux generated by passing the signal current in the light coil 45 from the light electrode 46 will be led to the magnetic pole core which consists of a lower magnetic pole layer 44 and an up magnetic pole layer 47, magnetic flux will leak and come out of it outside with the record gap formed of a light gap layer in the about 48 light pole at the nose of cam of the up magnetic pole layer 47, and a signal will be recorded on a record medium. Moreover, conversely, the magnetic flux from a record medium can be detected with a magnetic pole core, a signal can also be reproduced, the width of face of the light pole 48 at the nose of cam of the up magnetic pole layer 47 turns into the width of recording track, and field recording density is prescribed by this width of recording track.

[0005] On the other hand, the reproduction principle in an MR head uses the phenomenon in which the electric resistance of the magnetic thin film which constitutes the magnetoresistance-effect element 42 changes with the magnetic fields from a record medium, when fixed sense current is passed from the lead electrode 43.

[0006] However, there is a problem that the shielding effect and magnetic-recording capacity over the magnetic field noise and drive magnetic field of the frequency of 10MHz - 10MHz of numbers in a magnetic-shielding layer, or the upper part and a lower magnetic pole layer in the compound-die thin film magnetic head decline greatly, and tend to cause poor record for an eddy current loss. This is for an eddy current loss's becoming large as it becomes a RF, and causing the fall of the record magnetic field strength by the skin effect. What is necessary is just to make specific resistance rho high, since an eddy current loss is in the relation between specific resistance rho and an inverse proportion in order to suppress such an eddy current loss.

[0007] namely, eddy current loss We per [which flows the magnetic substance when a coil is twisted around the pillar-like magnetic substance of radius t [m] and coil current is passed] unit volume They are frequency and Bm about the radius of a magnetic thin film, i.e., thickness, and f [MHz] in tau [m]. When [Wb/m2] was made into intensity of magnetization and rho [omega-m] is made into specific resistance We =pi2, tau2, f2, and Bm 2/4rho ... (1),

Since it is come out and expressed, if specific resistance rho is large, or if a radius tau is small, it is an eddy current loss We. It becomes small.

[0008] Moreover, threshold frequency fg They are specific resistance and t about rho The thickness of a magnetic film, and mu 0 Space permeability and mud When it considers as the permeability of a magnetic film fg =4rho/(pi-mu 0 and mud, and t2) ... (2),

Since it is come out and expressed, if specific resistance rho is large, or if thickness t is small, it is threshold frequency fg. It becomes large.

[0009] However, since itself consists of permalloys of nickel82Fe18 grade, specific resistance rho is as small as about 20 microomegacm, and since it is really by plating formed by the comparatively thick film of formation, tau or t becomes large, and the conventional up magnetic pole layer 47 and the conventional light pole 48 are an eddy current loss We. It is surely large and is threshold frequency fg. There is a problem of surely becoming small.

[0010] On the other hand, if thickness t of a magnetic film is made thin, it will be an eddy current loss We. It is small and is threshold frequency fg. Although it can enlarge, when it does so, the problem that the amount of total magnetic flux decreases will arise.

[0011] In order to solve such a problem, it is proposed that development of quantity rho magnetic pole material is furthered from the permalloy of nickel82Fe18 grade, have magnetic properties almost equivalent to a permalloy, and specific resistance rho uses the NiFeMo alloy film of rho>=20micro omegacm as a RF magnetic pole material (refer to JP,9-63016,A, if required).

[0012]

[Problem(s) to be Solved by the Invention] However, the NiFeMo alloy film concerning an above-mentioned proposal is magnetostriction constant lambdas. It is large by the forge fire exceeding 5x10-6, and 180 degrees C - 300 degrees C heat treatment is needed for magnetic-domain control, and there is a problem that there is a possibility of having a bad influence on the

magnetoresistance-effect element from which this heat treatment constitutes the reproduction section formed before magnetic pole formation.
[0013] That is, in order to make high the permeability of the magnetic pole layer of the thin film magnetic head, it is magnetostriction constant lambdas. It is necessary to make it small (if required work besides Matsumoto, "magnetic-recording engineering", 179, Kyoritsu shuppan Co., Ltd. ******). to near the nose of cam of a magnetic pole [p.] That is, magnetic flux can be spread by spin rotation in a hexagon-head magnetic domain by performing magnetic-domain control so that a hexagon-head magnetic domain may be formed to near the light pole, and the reversible magnetization process excellent in high-frequency response can be produced.
[0014] Here, the case of the up magnetic pole layer of a conventionally general configuration is taken up, and the ideal magnetic-domain structure in an up magnetic pole layer is explained with reference to drawing 7 .
Drawing 7 reference drawing 7 is the plan of the up magnetic pole layer 47, and the magnetization direction shown by the arrow in drawing is wanted to flow back through the triangular magnetic domain 51 from which the hexagon-head magnetic domain 50 used as the main magnetic domain turns into a reflux magnetic domain which was formed even in the about 48 light pole, and was adjoined and formed in the hexagon-head magnetic domain 50 as ideal magnetic-domain structure.
[0015] As mentioned above, in order to raise the RF property of magnetic pole material, it is raise in specific resistance, and magnetostriction constant lambdas. Three points of minute-izing and magnetic-domain control are important, and it is necessary to skip the process which does a bad influence for the magnetoresistance-effect element which constitutes the reproduction section formed before magnetic pole formation of heat treatment etc.
[0016] Therefore, in a magnetic material, the magnetic head, or a magnetic device, this invention aims at forming good magnetic-domain structure, without requiring heat treatment while it improves a RF property by controlling the composition ratio of NiFeMo.
[0017]
[Means for Solving the Problem] Drawing 1 is explanatory drawing of the theoretic composition of this invention, and explains the The means for solving a technical problem in this invention with reference to this drawing 1 .
[0018] In addition, drawing 1 is the composition diagram showing the suitable NiFeMo composition range.
In the magnetic material which the drawing 1 reference this invention becomes from (1) nickel, and Fe and Mo 15 - 21 atom % and Mo for 77 - 82 atom % and Fe under by 6 atom % [the composition ratio of NiFeMo] [nickel] And magnetostriction constant lambdas In choosing it as the range used as s<=0 or -1x10-6 <=lambda(2) nickel, and the magnetic material that consists of Fe and Mo It is [ratio / composition / of NiFeMo / nickel] under 6 atom % about 15 to 21 atom %, and Mo in 77 to 82 atom %, and Fe, and is magnetostriction constant lambdas. It is characterized by choosing it as the range used as 0 <=lambdas<=1x10-6.
[0019] The magnetic material chosen on condition that (1) among the above is suitable as a magnetic pole layer of the general write head of a configuration which has compressive stress. The magnetic material chosen on condition that (2) on the other hand is suitable as a magnetic pole layer of the write head of a configuration which has hauling stress.
[0020] When the magnetic material of high permeability which was excellent in the RF property by controlling the composition ratio of NiFeMo can be obtained so that the above conditions may be fulfilled, and an up magnetic pole layer is constituted from a magnetic material film of such a composition ratio, speaking of the magnetic material of the conditions of (1), the magnetic-domain structure near the ideal in which the hexagon-head magnetic domain was formed to near the point of an up magnetic pole layer is acquired.
[0021] (3) Moreover, set to the above (1) and (2) and this invention is the coercive force Hc of a magnetic material. It is characterized by choosing the composition ratio of NiFeMo so that it may be set to Hc <=1Oe.
[0022] Thus, coercive force Hc of a magnetic material By choosing the composition ratio of NiFeMo so that it may be set to Hc <=1Oe, the same outstanding ********** as a permalloy

required for a magnetic pole layer can be obtained.
[0023] (4) Moreover, this invention is characterized by choosing the composition ratio of NiFeMo so that the specific resistance rho of a magnetic material may be set to rho>=20microomegacm in either of above-mentioned (1) - (3).
[0024] Thus, by choosing the composition ratio of NiFeMo so that the specific resistance rho of a magnetic material may be set to rho>=20microomegacm, the magnetic material of high specific resistance can be obtained from the permalloy of the conventional nickel82Fe18 grade, and it is We about an eddy current loss by it. It is small and is threshold frequency fg. It can enlarge.
[0025] (5) Moreover, set to either of above-mentioned (1) - (4), and this invention is the saturation magnetic flux density Bs of a magnetic material. It is characterized by choosing the composition ratio of NiFeMo so that it may be set to Bs >=0.8T.
[0026] Thus, saturation magnetic flux density Bs of a magnetic material By choosing the composition ratio of NiFeMo so that it may be set to Bs >=0.8T, it can consider as saturation magnetic flux density of the same grade as a permalloy, therefore record magnetic field strength of the same grade as a permalloy can be maintained.
[0027] (6) Moreover, this invention is characterized by constituting a magnetic pole layer using one magnetic material of above-mentioned (1) - (5) in the magnetic head.
[0028] Thus, using one magnetic material of above-mentioned (1) - (5), a magnetic pole layer and by constituting an up magnetic pole layer especially, the magnetic-domain structure near [to / near the point of an up magnetic pole layer] an ideal is acquired, and the thin film magnetic head or the compound-die thin film magnetic head of the induction type which has the RF property which was excellent with it can be realized.
[0029] (7) Moreover, this invention is characterized by constituting a magnetic-shielding layer using one magnetic material of above-mentioned (1) - (4) in the magnetic head.
[0030] Thus, by constituting the magnetic-shielding layer which puts a magnetoresistance-effect element using one magnetic material of above-mentioned (1) - (4), the shielding effect to the magnetic field noise and drive magnetic field of high frequency can be kept good, and the MR head for reproduction or the compound-die thin film magnetic head which has the RF property which was excellent with it can be realized.
[0031] (8) Moreover, this invention is characterized by constituting a magnetic-shielding layer using the magnetic material of the above (1) or either of (4) in a magnetic device.
[0032] Thus, the use of a magnetic-shielding layer is not restricted to the magnetic head, and can be used in magnetic-measurement equipment etc. also as a magnetic-shielding layer for shielding the external magnetic field used as a noise.
[0033]
[Embodiments of the Invention] Below in [the magnetic pole layer of the general write head of a configuration which has the 1st embodiment - compressive stress], although the thin film magnetic head of the form of operation of this invention is explained, first of all with reference to drawing 2 or drawing 4 , the NiFeMo composition dependency of many magnetic properties in a NiFeMo (nickel-iron-molybdenum) alloy film is explained. Illustrating as the first embodiment is about the case of the magnetic pole layer of the write head which carried out the form where the antenna-like part which should serve as a light port was added to the five-cornered (configuration by which the triangle was added to one side of parallelograms, such as a square) vertex of the shape of the home base generally known.
[0034] The NiFeMo alloy film in this case forms membranes with electrolysis plating used for the manufacture method of the usual magnetic pole layer, it is referred to as 1-3 micrometers as thickness, the magnetic field of 400 [Oe] is only impressed as membrane formation conditions at the time of membrane formation, and special processing is omitted. In addition, the composition ratio of the chemical to be used etc. is as having indicated the detail of the membranous formation method to Japanese Patent Application No. No. 220011 [ten to]. If outline explanation is given, a NiFeMo (nickel-iron-molybdenum) alloy film will be formed with electroplating using the plating bath which contains the organic acid which is the salt of nickel ion, Fe ion, Mo ion, a hydroxy acid, or a hydroxy acid, for example. In this case, concentration of the aforementioned organic acid under plating bath is made into 0.001 or more mol/l, and is made

into three to 20 times of the concentration of the aforementioned Mo ion under plating bath.
Drawing 2 (a) reference drawing 2 (a) is magnetostriction constant lambdas. It is drawing showing the measurement result of a NiFeMo composition dependency, and is magnetostriction constant lambdas. The optical-lever method was used on the occasion of measurement.
[0035] It is magnetostriction constant lambdas as nickel composition ratio increases so that clearly from drawing, and as Mo composition ratio decreases. If it falls, nickel composition ratio is set to lambdas =0 [near the about 80 atom % (at%)] and nickel composition ratio increases more than it, it is magnetostriction constant lambdas. If it becomes negative and nickel composition ratio becomes less than it, it is magnetostriction constant lambdas. It just becomes.
Drawing 2 (b) reference drawing 2 (b) is about lambdas =0, and has a negative value. It is drawing showing magnetic-domain structure when Mo composition ratio forms the up magnetic pole layer 11 with the NiFeMo alloy film of about 2.0 atom %. Copy the state where microscope observation of the result was carried out, using the BITTA method make the magnetic domain wall 13 of the boundary of a magnetic domain collect the colloid of an iron oxide, and so that clearly from drawing It was observed that it is in the state near ideal magnetic-domain structure even if the hexagon-head magnetic domain 14 is constituted to near the light pole 12 and it does not add special heat treatment.
Drawing 2 (c) reference drawing 2 (c) is about lambdas =0, and has a positive value. Are drawing showing magnetic-domain structure when Mo composition ratio forms the up magnetic pole layer 11 with the NiFeMo alloy film of about 2.5, copy the state where microscope observation of the result similarly depended on the BITTA method was carried out, and so that clearly from drawing there are few hexagon-head magnetic domains 14 as a whole, and a large majority of magnetic domains constitute by the triangular magnetic domain 15 -- having -- **** -- things -- it was observed and was not desirable magnetic-domain structure
[0036] therefore, in order to form the up magnetic pole layer 11 which has good magnetic-domain structure, without adding heat treatment special [for magnetic-domain control] Magnetostriction constant lambdas It is necessary to choose the composition ratio of the range used as lambdas <=0 and, and is magnetostriction constant lambdas. When it is negative, when the absolute value is large Since a good magnetic domain is not obtained, it is necessary to choose the composition ratio of NiFeMo as the whole, so that it may be set to -1x10-6 <=lambdas <=0 so that it may be set to lambdas >=-1x10-6.
Drawing 3 (a) reference drawing 3 (a) is coercive force Hc. It is drawing showing the measurement result of a NiFeMo composition dependency, and is coercive force Hc. On the occasion of measurement, the VSM (Vibrating SampleMagnetometer:oscillating sample type magnetometer) method was used.
[0037] the range surrounded as the solid line so that clearly from drawing -- Hc -- < -- since it is set to 1 [Oe], in order to obtain the magnetic film of Hc <=1[Oe] -- 75at% -- <=nickel composition ratio -- <=83at%15at% -- <=Fe composition ratio -- <=22at%0at% -- it may be necessary to be <Mo composition ratio <=6at%
Drawing 3 (b) reference drawing 3 (b) is drawing showing the measurement result of the NiFeMo composition dependency of specific resistance rho, and 4 terminal method was used for it on the occasion of measurement of specific resistance rho.
[0038] Although specific resistance rho increased with the increase in Mo composition ratio so that clearly from drawing, in the range shown in drawing, specific resistance rho was set to rho>=20microomegacm in all composition ratios, and it was checked that it can be made high specific resistance from a permalloy.
Drawing 4 (a) reference drawing 4 (a) is saturation magnetic flux density Bs. It is drawing showing the measurement result of the NiFeMo composition dependency of rho, and is saturation magnetic flux density Bs. In the case of measurement, it is coercive force Hc. The VSM method was used like measurement.
[0039] It is saturation magnetic flux density Bs so that clearly from drawing. It is set to Bs >=0.8T in the range shown in drawing although there was an inclination for there to be an inclination which increases with the increase in Fe composition ratio, and to fall with the increase in nickel composition ratio, and is the saturation magnetic flux density Bs of the same

grade as a permalloy. Being obtained was checked.
Drawing 4 (b) reference drawing 4 (b) is nickel80Fe17.5Mo2.5 used as magnetostriction constant lambdas =-5x10-7, coercive force Hc =0.5Oe, specific resistance rho=47microomegacm, and saturation-magnetic-flux-density Bs =0.95T. It is drawing showing the measurement result of the permeability at the time of forming permalloy nickel80Fe20 in thickness of 2 micrometers.
[0040] if nickel80Fe20 exceeds about 20MHz so that clearly from drawing -- nickel80Fe17.5Mo2.5 although it will become 1000 or less if effective-permeability mu' begins to fall and about 40MHz is exceeded -- nickel80Fe17.5Mo2.5 In the case, effective-permeability mu' is over 1000 to the range of about about 70MHz, and improvement in the permeability of a 100MHz band was checked.
[0041] In addition, mu" is invalid permeability.
[0042] If the above result is summarized, in order to form the magnetic film of a good RF property with a NiFeMo alloy film a NiFeMo composition ratio -- 75at% -- <=nickel composition ratio -- <=83at%15at% -- <=Fe composition ratio -- <=22at%0at%, if it becomes a requirement to consider as <Mo composition ratio <=6at% and safety is expected more 77at(s)% -- <=nickel composition ratio -- <=82at%15at% -- <=Fe composition ratio -- <=21at%0at% -- it is desirable to consider as <Mo composition ratio <6at%
[0043] Moreover, it is magnetostriction constant lambdas so that clearly from drawing 2 , in order to acquire the magnetic-domain structure near an ideal within the limits of the above-mentioned composition ratio. It becomes a requirement to be referred to as -1x10-6 <=lambdas <=0.
[0044] furthermore, such conditions -- in addition, the above-mentioned terms and conditions in order to acquire a good RF property certainly -- adding -- coercive force Hc, specific resistance rho, and saturation magnetic flux density Bs ******** -- Hc -- <=1[Oe] rho>=20microomegacmBs It is desirable to choose the composition ratio of NiFeMo so that at least one of >=0.8T conditions may be filled.
[0045] Next, the form of the 1st and operation of the 2nd of this invention about the concrete composition of the thin film magnetic head using the NiFeMo alloy film of the composition ratio of the above-mentioned range or the compound-die thin film magnetic head is explained with reference to drawing 5 .
[0046] In addition, the magnetic-substance film in this case is nickel80Fe17.5Mo2.5 used here on the occasion of measurement of the permeability of drawing 4 (b) although what thing could be used as long as it was the composition ratio which fulfills the above-mentioned terms and conditions. It used.
[0047] Therefore, magnetostriction constant lambdas of the magnetic-substance film in this case, coercive force Hc, specific resistance rho, and saturation magnetic flux density Bs It is set to lambdas =-5x10-7, Hc =0.5Oe, rho=47microomegacm, and Bs =0.95T as mentioned above.
Drawing 5 (a) reference drawing 5 (a) is the rough important section cross section of the thin film magnetic head of the induction type of the form of operation of the 1st of this invention.
First, on the aluminum2 O3-TiC substrate 21 used as the parent of a slider aluminum 2O3 A film 22 is minded. 50-100A in thickness, 50A Ta layer, And by applying and carrying out patterning of the resist film, after forming the plating base layer (not shown) which consists of 1000A or less in thickness, and a 500A NiFe alloy The resist mask (not shown) which has predetermined opening is formed, and the lower magnetic pole layer 23 in which it is thin with electrolysis plating from nickel80Fe17.5Mo2.5 2.5-4.0 micrometers, for example, 3.0 micrometers, alloy is formed. subsequently After removing a resist mask, the outcrop of a plating base layer is removed by the ion milling method using Ar ion.
[0048] By the sputtering method, 0.2-0.6 micrometers in subsequently, thickness For example, after making 0.4-micrometer aluminum 2O3 deposit and considering as the light gap layer 24, the lower layer insulation film 25 with which it is thin from a 3.0-4.0 micrometers, for example, 3.5 micrometers, resist is minded. When thickness prepares and carries out patterning of the 2.5-4.0 micrometers, for example, 3.0 micrometers, Cu film The light flat-surface spiral-like coil 26 around which the connection of the up magnetic pole layer 28 formed behind and the lower magnetic pole layer 23 is wound two or more times, and the light electrode of the ends are

formed. subsequently Again, thickness forms the up layer insulation film 27 which consists of a 3.0-4.0 micrometers, for example, 3.5 micrometers, resist, and covers the light coil 26.
[0049] In addition, the thickness of the light gap layer 24 in this case becomes the interval of a magnetic gap, i.e., gap length.
[0050] 1000A or less in 50-100A in thickness, 50A Ti layer, and thickness and a 500A NiFe film are formed one by one by the sputtering method, and a plating base layer (not shown) is formed. subsequently, subsequently After applying a resist layer, the resist mask (not shown) which has opening of the configuration corresponding to the up magnetic pole layer 28 by exposing and developing negatives is prepared, and this resist mask is used as a mask. with electrolysis plating The up magnetic pole layer 28 from which it was [layer] thin from nickel80Fe17.5Mo2.5 2.0-4.0 micrometers, for example, 3.0 micrometers, alloy, and the point became the light pole 29 of **** is formed.
[0051] After removing a resist mask, the outcrop of a plating base layer is removed by giving ion milling using Ar ion. subsequently, subsequently A substrate is cut, after preparing 2Oaluminum3 film in the whole surface and considering as a protective coat (not shown). By performing slider processing including the grinding for adjusting the length of the light pole 29, i.e., the depth of gap, polish, etc., it excels in a RF property and the thin film magnetic head of the induction type of high recording density is completed.
[0052] In the gestalt of this 1st operation, as the lower magnetic pole layer 23 and an up magnetic pole layer 28, since nickel80Fe17.5Mo2.5 alloy is used, it can consider as the magnetic-domain structure near the ideal in which the thin film magnetic head excellent in the RF property could be constituted, and the hexagon-head magnetic domain was formed to near the light pole 29 in the up magnetic pole layer 28.
Drawing 5 (b) reference drawing 5 (b) is the rough important section cross section of the compound-die thin film magnetic head of the gestalt of operation of the 2nd of this invention. 2Oaluminum3 film 22 is minded on the aluminum2O3-TiC substrate 21 used as the parent of a slider. first, thickness The lower shield layer 30 which consists of nickel80Fe17.5Mo2.5 2.0-4.0 micrometers, for example, 3.0 micrometers, alloy is formed. After forming the magnetoresistance-effect element 32 which consists of a laminated structure of NiFe, Ti, and NiFeCr etc. through the consisting [of aluminum 2O3] lower lead gap layer 31 and carrying out patterning to a predetermined configuration, The electric conduction film which consists of Au etc. is made to deposit on the ends of the magnetoresistance-effect element 32, a lead electrode (not shown) is formed, and, subsequently the up lead gap layer 33 which consists of aluminum 2O3 is formed again.
[0053] Like the gestalt of the 1st operation of the above henceforth on the up lead gap layer 32 By applying and carrying out patterning of the resist film, after forming the plating base layer (not shown) which consists of 1000A or less in 50-100A in thickness, 50A Ta layer, and thickness, and a 500A NiFe alloy The resist mask (not shown) which has predetermined opening is formed. with electrolysis plating thickness The lower magnetic pole layer 23 which serves as the up shield layer which consists of nickel80Fe17.5Mo2.5 2.5-4.0 micrometers, for example, 3.0 micrometers, alloy is formed. subsequently After removing a resist mask, the outcrop of a plating base layer is removed by the ion milling method using Ar ion.
[0054] By the sputtering method, 0.2-0.6 micrometers in subsequently, thickness For example, after making 0.4-micrometer aluminum 2O3 deposit and considering as the light gap layer 24, the lower layer insulation film 25 with which it is thin from a 3.0-4.0 micrometers, for example, 3.5 micrometers, resist is minded. When thickness prepares and carries out patterning of the 2.5-4.0 micrometers, for example, 3.0 micrometers, Cu film The light electrode which makes the light coil 26 of the shape of a flat-surface spiral which rolls the connection of the up magnetic pole layer 28 formed behind and the lower magnetic pole layer 23 two or more times, and its ends is formed. subsequently Again, thickness forms the up layer insulation film 27 which consists of a 3.0-4.0 micrometers, for example, 3.5 micrometers, resist, and covers the light coil 26.
[0055] 1000A or less in 50-100A in thickness, 50A Ti layer, and thickness and a 500A NiFe film are formed one by one by the sputtering method, and a plating base layer (not shown) is formed. subsequently, subsequently After applying a resist layer, the resist mask (not shown) which has

opening of the configuration corresponding to an up magnetic pole layer by exposing and developing negatives is prepared, and this resist mask is used as a mask. with electrolysis plating The up magnetic pole layer 28 from which it was [layer] thin from nickel80Fe17.5Mo2.5 2.0-4.0 micrometers, for example, 3.0 micrometers, alloy, and the point became the light pole 29 of **** is formed.
[0056] After removing a resist mask, the outcrop of a plating base layer is removed by giving ion milling using Ar ion. subsequently, subsequently A substrate is cut, after preparing 2Oaluminum3 film in the whole surface and considering as a protective coat (not shown). By performing slider processing including the grinding for adjusting the length of the light pole 29, i.e., the depth of gap, polish, etc., it excels in a RF property and the compound-die thin film magnetic head of high recording density is completed.
[0057] In the gestalt of this 2nd operation, since the magnetoresistance effect element 32 which constitute the MR head section for reproduction be pinch by the lower magnetic pole layer 23 used as the lower shield layer 31 and up shield layer which consist of nickel80Fe17.5Mo2.5 alloy, it become possible to keep good the shielding effect to about 100MHz the magnetic field noise and drive magnetic field of a RF, and can expect making re-biodegradation ability high by it.
[0058] Moreover, since the up magnetic pole layer 28 also uses and constitutes nickel80Fe17.5Mo2.5 alloy also in this case Since it can consider as the magnetic-domain structure near the ideal in which the hexagon-head magnetic domain was formed to near the light pole 29 and heat treatment after formation of the magnetoresistance-effect element 32 becomes unnecessary by it, without heat-treating special RF record is attained not having a bad influence on the magnetoresistance-effect element 32 which constitutes the MR head section for reproduction, and maintaining a high reproduction output.
The case where replaced with the configuration which has the compressive stress known by the general **** target which illustrated the flat-surface configuration of [the magnetic pole layer of the write head of a configuration which has the 2nd embodiment - tensile stress], next the magnetic pole layer of the write head as the 1st embodiment, and it replaces with the configuration which has tensile stress is explained. Thus, what is necessary is just to prepare large opening into the pentagon explained in the 1st embodiment, if the magnetic pole layer which has tensile stress is illustrated simply. Below, a principle is first explained in explaining a detail. In order to form reflux magnetic-domain structure to the point of the light pole and to form the magnetic head with a good property, he must be conscious of the anisotropy produced in the direction of magnetic pole length by the elastic anisotropy energy. When setting to theta the angle on which lambda makes a magnetostriction and sigma, spontaneous magnetization, and tension sigma make tension, elastic anisotropy-energy E follows the following formulas. There is a thing of magnetostriction positive/negative as an E=-(3/2) lambdasigmacos2theta magnetic-head material, and tension has a tensile stress (sigma>0). Since an elastic magnetic anisotropy arises so that E may be made into the minimum, theta= 90 degrees turns into theta= 0 degree by lambda> 0 lambda< 0. That is, in lambda< 0, an anisotropy is produced in sigma and the right-angled direction, and an anisotropy is produced in sigma and this direction in lambda> 0. Moreover, it changes with magnetic pole configurations, and works in the direction of magnetic pole length (the direction of y) in the configuration where a magnetic pole is long, and a magnetic pole commits the direction of a tensile stress crosswise [magnetic pole] (x directions) in a broad configuration. This is because a tensile stress works to the relatively longer one when length is geometrically compared with width of face. When the material of a right magnetostriction and a tensile stress is used so that clearly [in the above-mentioned formula], that what is necessary is just to use material which serves as a right magnetostriction in a magnetic pole configuration x>y, then when it is good and becomes x>y by short yoke-ization conversely, at this time, reflux magnetic-domain structure is formed to a magnetic pole nose of cam, and the magnetic head with a good property can be formed. By the way, what is necessary is just to make it the structure which prepared hollow in the center section of the magnetic pole layer, in order to change without the magnetic pole layer of the write head changing sharply the formation process of the shape of a general pentagon of having compressive stress so that it may have a tensile stress.

Drawing 8 reference drawing 8 is the ** type plan of the ideal magnetic-domain structure in connection with the 2nd operation gestalt of this invention, and draws the ideal magnetic-domain structure model of the magnetic pole layer of the write head prepares hollow and it was made to have a tensile stress. In the magnetic pole layer drawn on this drawing, although facies followed the form of the 1st operation gestalt fundamentally, since they prepared the centrum (back gap) in the interior of magnetic layer material, a tensile stress comes to produce them. Although the reflux magnetic-domain structure which consists of a hexagon-head magnetic domain and a triangular magnetic domain towards the magnetic pole nose of cam located in down [in a magnetic pole layer and on drawing] from a back gap is formed in this magnetic pole layer, propagation of the magnetic flux which the spin in a hexagon-head magnetic domain rotates, and contributes to record reproduction by forming a hexagon-head magnetic domain to a point in this way is performed with high speed and sufficient repeatability from a back gap to a magnetic pole nose of cam. In the example shown in drawing 8 , although generated from the back gap in the direction turned to at the nose of cam of a magnetic pole, tensile-stress sigma is adjusting the breadth of a magnetic pole layer, and the lengthwise length (the length to the direction prolonged at the nose of cam of a magnetic pole from a back gap), and since it can also be made to be generated in the direction of [from a back gap] a magnetic pole nose of cam, and the direction which goes direct, below, it explains this, quoting drawing 9 .

[0059] Drawing 9 (A) and (B) are the ** type plans used as the example of observation of the magnetic-domain structure in connection with the 2nd operation gestalt of this invention. When Breadth x is shorter than longwise [y], the width of face of a magnetic pole draws (A) about the case of being longer, compared with the length of a magnetic pole, and on the other hand, when Breadth x is longer than longwise [y], the width of face of a magnetic pole draws (B) about the case of being shorter, compared with the length of a magnetic pole. Although the tensile stress generally worked to the relatively longer one when the length and width of face of a magnetic pole were compared, the magnetic-domain observation result under a car microscope was what supports this. That is, in the case of drawing 9 (A), it has checked under the car microscope that tensile-stress sigma arose in the length direction of a magnetic pole, and tensile-stress sigma has arisen crosswise [of a magnetic pole] in being drawing 9 (B) on the other hand. Drawing 10 is the ** type plan of the magnetic pole layer of the write head based on the 2nd embodiment of this invention. The length of 45 micrometers and a magnetic pole can be set to 35 micrometers for the width of face of a magnetic pole, and it can use as a magnetic pole layer of the write head by setting magnetic pole layer material to 50NiFe(s) (right magnetostriction). Next, the embodiment in the case of using the magnetic pole layer of the write head shown in drawing 10 as a part of general compound-die MR head is explained according to drawing 11 . Drawing 11 is the ** type view (cross-section structure from a ** type plan (a), a magnetic-domain structure model plan (b), and a magnetic pole nose of cam (c)) showing the example of application of the compound-die magnetic head based on the 2nd embodiment of this invention. The common cross section of the compound-die magnetic head which unified a read head and the write head is carrying out a configuration like drawing 11 (c), if it draws typically. In order to eliminate the influence of the MAG of the circumference which becomes the hindrance at the time of reading the magnetic-recording information which prepared MR element which bears reading and was recorded into the magnetic-recording medium, a magnetic-shielding layer is prepared in the both sides of MR element. Furthermore, an up magnetic pole is prepared in the outside of three layer structures of this magnetic-shielding layer / MR element / magnetic-shielding layer, and this writes in. The composition of an up magnetic pole should just be a configuration as shown in drawing 10 . The plan which looked at the compound-die magnetic head shown in drawing 11 (c) from the top is as being shown in drawing 11 (a). Among drawing 11 (a), although a magnetic-shielding layer is prepared in the bottom of the up magnetic pole of the configuration shown in drawing 10 , a magnetic-shielding layer is larger than an up magnetic pole enough in this case. The length of a magnetic-shielding layer is 65 micrometers to the width of face of a magnetic-shielding layer being 70 micrometers to the width of face of an up magnetic pole being 45 micrometers, and the length of an up magnetic pole being 35 micrometers. When patterning of the magnetic-shielding layer is carried out to a square, the magnetic-domain structure model

changes like the combination of a simple hexagon-head magnetic domain and a triangular magnetic domain, as shown in drawing 11 (b).
[0060] Next, what is necessary is just to make it structure which is indicated by drawing 5 according to having explained as an operation gestalt of the above 1st, in applying the compound-die magnetic head indicated to above-mentioned drawing 11 to the concrete composition of the thin film magnetic head using the NiFeMo alloy film of the composition ratio of the above-mentioned range, or the compound-die thin film magnetic head. Therefore, it omits explaining the process of drawing 5 repeatedly here. In addition, although what thing was sufficient as the magnetic-substance film in this case as long as it was the composition ratio which fulfills the above-mentioned terms and conditions, same nickel80Fe17.5Mo2.5 as having used on the occasion of measurement of the permeability of drawing 4 (b) was used for it here. Magnetostriction constant lambdas of the magnetic-substance film in this case, coercive force Hc, specific resistance rho, and saturation magnetic flux density Bs It is set to lambdas =+5x10-7, Hc =0.5Oe, rho=47microomegacm, and Bs =0.95T as mentioned above.
[0061] in the gestalt of another operation, since the magnetoresistance effect element 32 which constitute the MR head section for reproduction be pinch by the lower magnetic pole layer 23 used as the lower shield layer 31 and up shield layer which consist of nickel80Fe17.5Mo2.5 alloy, it become possible to keep good the shielding effect to about 100MHz the magnetic field noise and drive magnetic field of a RF, and can expect make re-biodegradation ability high by it.
[0062] Moreover, since the up magnetic pole layer 28 also uses and constitutes nickel80Fe17.5Mo2.5 alloy also in this case Since it can consider as the magnetic-domain structure near the ideal in which the hexagon-head magnetic domain was formed to near the light pole 29 and heat treatment after formation of the magnetoresistance-effect element 32 becomes unnecessary by it, without heat-treating special RF record is attained not having a bad influence on the magnetoresistance-effect element 32 which constitutes the MR head section for reproduction, and maintaining a high reproduction output.
[0063] As mentioned above, although the gestalt of each operation of this invention has been explained As a magnetic material which this invention is not restricted to the operation gestalt which gave [above-mentioned] explanation, and various kinds of change is possible for it, for example, constitutes an up magnetic pole layer etc. Magnetostriction constant lambdas of the above that it is [and] the range of not the thing restricted to nickel80Fe17.5Mo2.5 alloy but the composition ratio mentioned above, coercive force Hc, specific resistance rho, and saturation magnetic flux density Bs What is necessary is just the NiFeMo alloy which fulfills the related terms and conditions. Moreover, what is necessary is to be applied also to the independent MR head only for reproduction, and just to use the NiFeMo alloy which fulfills above-mentioned terms and conditions as an up-and-down magnetic-shielding layer like the compound-die thin film magnetic head in explanation of the gestalt of each above-mentioned operation, although explained as the thin film magnetic head or the compound-die thin film magnetic head of an induction type. Moreover, it applies also to any of not MR element of a common type but a GMR (huge magnetoresistance effect) element, and a spin bulb element, and the same effect is acquired.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is explanatory drawing of the theoretic composition of this invention.
[Drawing 2] Magnetostriction constant lambdas It is explanatory drawing of the NiFeMo composition dependency of magnetic-domain structure.
[Drawing 3] Coercive force Hc It is explanatory drawing of the NiFeMo composition dependency of specific resistance rho.
[Drawing 4] Saturation magnetic flux density Bs It is explanatory drawing of the NiFeMo composition dependency of a permeability property.
[Drawing 5] It is the rough cross section of the thin film magnetic head of the gestalt of operation of this invention.
[Drawing 6] It is the important section transillumination perspective diagram of the conventional compound-die thin film magnetic head.
[Drawing 7] It is the ** type plan of the ideal magnetic-domain structure in connection with the 1st operation gestalt of this invention.
[Drawing 8] It is the ** type plan of the ideal magnetic-domain structure in connection with the 2nd operation gestalt of this invention.
[Drawing 9] It is a ** type plan used as the example of observation of the magnetic-domain structure in connection with the 2nd operation gestalt of this invention.
[Drawing 10] It is the ** type plan of the magnetic pole layer of the write head based on the 2nd operation gestalt of this invention.
[Drawing 11] It is the ** type view (cross-section structure from a ** type plan (a), a magnetic-domain structure model plan (b), and a magnetic pole nose of cam (c)) showing the example of application of the compound-die magnetic head based on the 2nd operation gestalt of this invention.
[Description of Notations]
11 Up Magnetic Pole Layer
12 Light Pole
13 Magnetic Domain Wall
14 Hexagon-Head Magnetic Domain
15 Triangular Magnetic Domain
21 Aluminum2 O3-TiC Substrate
22 Aluminum 2O3 Film
23 Lower Magnetic Pole Layer
24 Light Gap Layer
25 Lower Layer Insulation Film
26 Light Coil
27 Up Layer Insulation Film
28 Up Magnetic Pole Layer
29 Light Pole
30 Lower Shield Layer
31 Lower Lead Gap Layer

32 Magnetoresistance-Effect Element
33 Up Lead Gap Layer
41 Lower Shield Layer
42 Magnetoresistance-Effect Element
43 Lead Electrode
44 Lower Magnetic Pole Layer
45 Light Coil
46 Light Electrode
47 Up Magnetic Pole Layer
48 Light Pole
49 Magnetic Domain Wall
50 Hexagon-Head Magnetic Domain
51 Triangular Magnetic Domain

[Translation done.]